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REPORT of the
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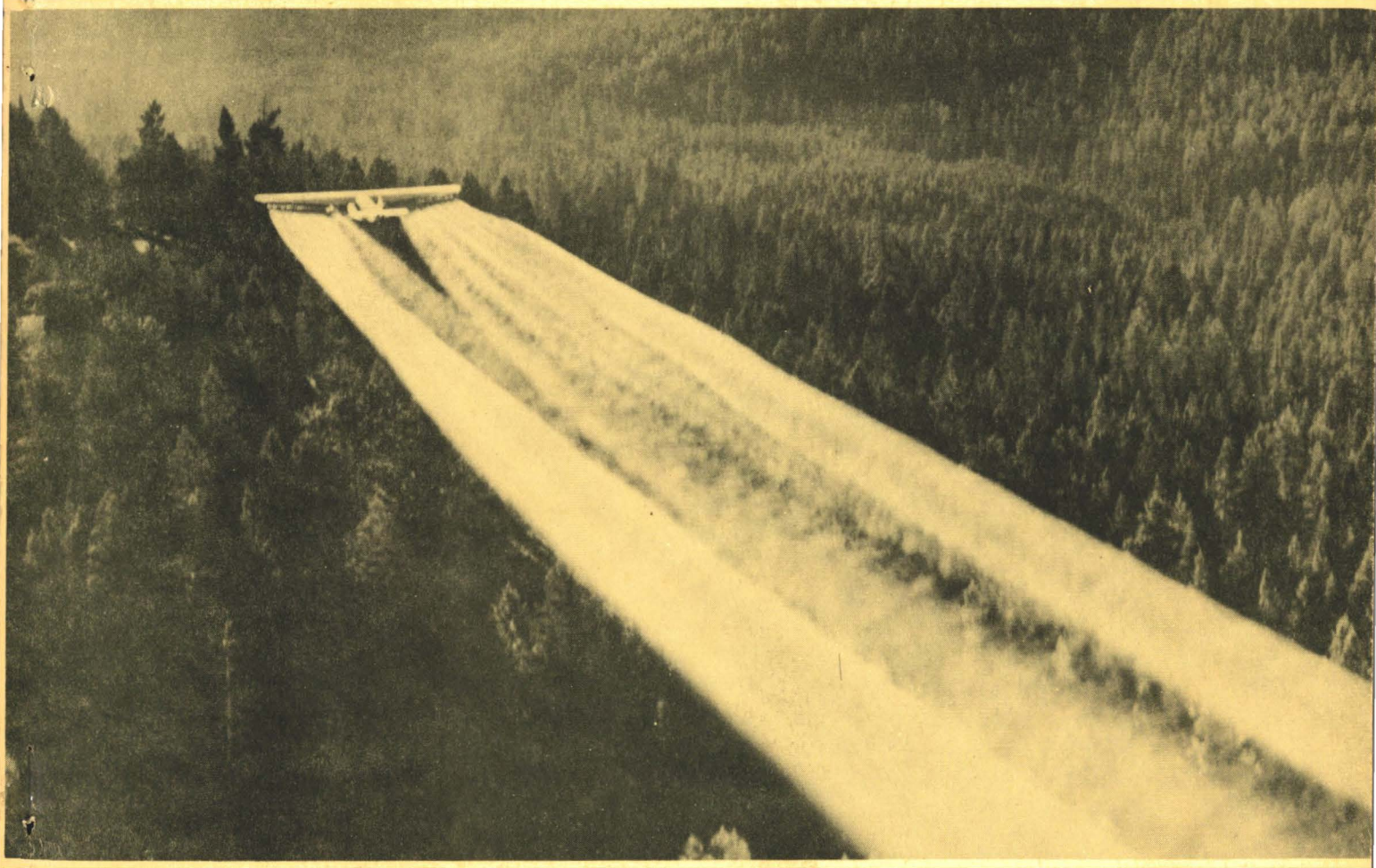

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Acknowledgment is made of cooperation and assistance received from many individuals, particularly the contractors and their staffs, whose efforts contributed so much to the success of the project. This cooperation has been characteristic of the entire spruce budworm control program in Oregon and Washington.

Acknowledgment is also made to the Supervisors and their staffs of the Malheur, Ochoco, and Wallowa-Whitman National Forests, and the Oregon State Board of Forestry for personnel, equipment, and supplies for the conduct of the project.

Credit is also due the Civil Aeronautics Administration and its agents for excellent work on safety features connected with aerial spraying operations.

COVER: Ford tri-motor spray plane applying DDT insecticide, Powder River Control Unit, 1955 Oregon Spruce Budworm Control Project.

REPORT OF THE 1955 OREGON SPRUCE BUDWORM CONTROL PROJECT

By

J. M. Whiteside
Entomologist
Pacific Northwest Forest and Range Experiment Station
Forest Service
U. S. Department of Agriculture

C. P. Wessela
Forester
Pacific Northwest Region
Forest Service
U. S. Department of Agriculture

and

L. M. Compton
Director of Insect Control
Oregon State Board of Forestry

April 1, 1956

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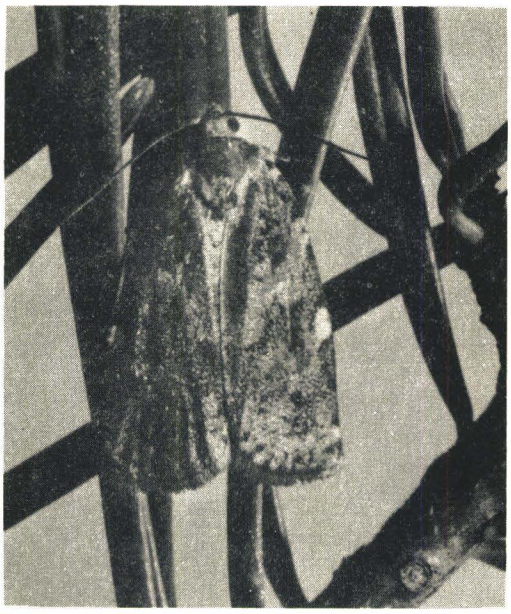
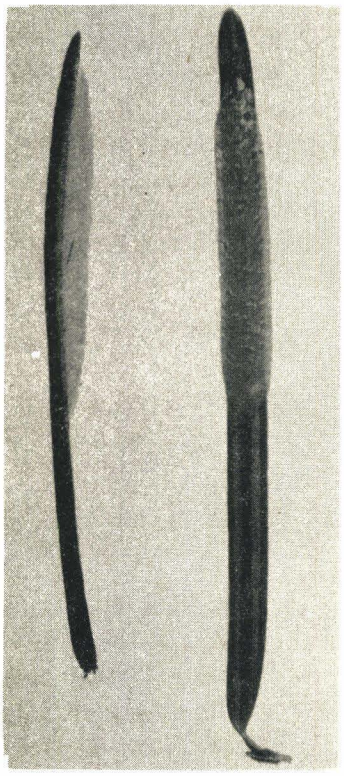
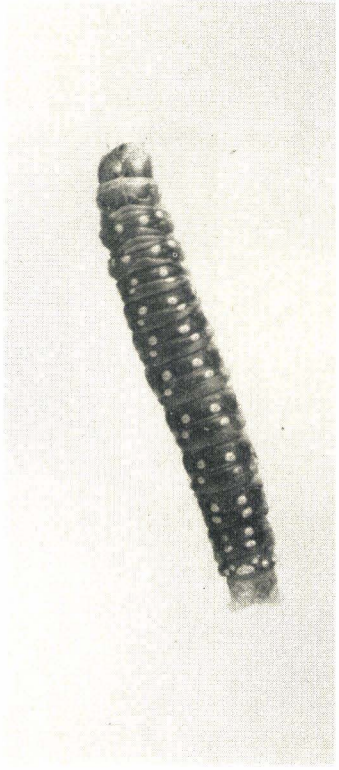
PLATE I. LIFE STAGES OF THE SPRUCE BUDWORM



Adult x4



Egg masses x4



Mature larva x4

Pupa x4

Frontispiece

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SUMMARY

Results of the 1955 Oregon Spruce Budworm Control Project are reported. This was the seventh consecutive project since 1949 in a cooperative control program recommended by the Northwest Forest Pest Action Committee.

Spraying operations in 1955 were confined to the Blue Mountains area of Oregon. They began June 27 and ended July 21. During this 25-day period there were 21 spraying days and 4 days on which operations were cancelled because of weather.

Good control (96.9%) of spruce budworm on 620,947 acres was obtained at a cost of $1.0598 per acre. This brought the total acreage successfully treated during the 7-year program to 3,839,611 acres.

Parasitism of budworm surviving spraying was determined by dissection of samples from each unit. Some 43.2 percent of the survivors were parasitized. Combined mortality from spraying and parasitism was 98.2 percent.

Services of 213 persons were required to conduct the 1955 project. In addition, the assistance of numerous mapmakers, radio technicians, and truck drivers contributed much to the project's success.

Only one lost-time accident occurred resulting in hospitalization of a spray plane pilot. This was the first serious accident since 1952.

Spray pilots were well briefed on block boundaries and there was little delay in completing the project from an operational standpoint. Compared to previous projects, there were relatively few missed portions of spray blocks and, consequently, a minimum of re-spraying was necessary.

A late cold spring retarded and caused marked uneven development of both budworm larvae and foliage, which resulted in many technical difficulties.

Precautions taken to avoid damage to agricultural lands, crops and fish were apparently successful. No damage has been reported.

Details of planning, operation, and biological investigations necessary to conduct a spruce budworm control project are discussed. Supporting data are presented in 16 tables, a graph showing status of the budworm epidemic, and a map showing units treated in 1955 and those brought under control from 1949 through 1954.

REPORT OF THE 1955 SPRUCE BUDWORM CONTROL PROJECT

INTRODUCTION

Aerial application of DDT for control of the spruce budworm, Choristoneura fumiferana (Clem.) in the Douglas-fir and true fir forests of Oregon and Washington has been in progress since 1949. This program, recommended by the Northwest Forest Pest Action Committee 1/, has been a cooperative undertaking of private, state, and federal owners and land-managing agencies in combating a serious menace to the fir forests of the two states.

Results of the 1955 control project are herein reported. This was the seventh consecutive project, during which 620,947 acres of epidemic infestations were successfully treated at a cost of $658,060.27 or $1.0598 per acre. The value of threatened timber on the control units has been conservatively estimated at $12 million.

Safety is of paramount importanceon these hazardous undertakings. Concerted efforts of ground personnel combined with the professional skill of flying personnel and their maintenance crews contributed to another excellent safety record. For the third successive year there were no fatalities. Although several minor accidents occurred, there was only one serious accident, which resulted in hospitalization of a spray plane pilot.

1/ The Northwest Forest Pest Action Committee, E. L. Kolbe, Chairman, is an informal group composed of numerous individuals and representatives of the following organizations:

Associated Forest Industries of Oregon
Industrial Forestry Association
Keep Oregon Green Association
Keep Washington Green Association
Oregon Extension Service
Oregon Forest Fire Association
Oregon State Board of Forestry
Oregon State College
Southern Oregon Conservation and Tree Farm Association
State College of Washington
Tree Farm Management Service
U. S. Bureau of Land Management
U. S. Forest Service
U. S. Office of Indian Affairs
U. S. Soil Conservation Service
University of Washington
Washington Forest Fire Association
Washington State Division of Forestry
Washington State Forestry Conference
Western Forest Industries Association
Western Forestry and Conservation Association
Western Pine Association

PROGRESS OF THE SPRUCE BUDWORM INFESTATION
AND CONTROL PROGRAM IN OREGON AND WASHINGTON SINCE 1944

The present spruce budworm epidemic in Oregon and Washington was discovered in its early stages in 1944 on the Heppner Ranger District, Umatilla National Forest, Oregon. The first surveys to determine the extent of this outbreak were made in 1947 2/. This survey revealed 908,000 acres of epidemic infestations mostly in the Blue Mountains area of the two states. At the peak of the epidemic in 1949 there were 2,276,000 acres of epidemic infestations.

To protect the Douglas-fir forests of Oregon and Washington from destruction by the budworm, an annual aerial spraying program, employing the techniques developed during a large-scale cooperative experiment in 1948 3/, has been in effect since 1949. The progress of the infestation and control program in the two states is shown by graph 1.

During seven years (1949-1955) of aerial spraying, 3,839,611 acres of epidemic infestations and buffer zones have been successfully treated (figure 1 in the Appendix), at a cost of about $4,045,000 or about $1.05 per acre. Spruce budworm mortality has averaged 98.2 percent. Only an occasional spray block has fallen below the 90 percent level, considered the minimum acceptable (table 1).

Significant accomplishments of the control program are as follows:

1. An epidemic which started in 1944 and reached a peak of 2,276,000 acres in 1949, has been reduced to 542,430 acres in 1955.

2. Acreage of heavy epidemic infestations, on which tree killing was in progress, was reduced from 887,000 acres in 1949 to 39,900 acres in 1955.

3. Areas on which a major portion of the fir stand has been killed total less than 10,000 acres.

4. Epidemic infestations have been eliminated in the western Oregon area and tree killing has been entirely prevented.

5. Epidemic infestations have been eliminated from the eastern Oregon Cascade area and tree killing has been kept to a low level.

6. Less than 1 percent of the treated acreage has had to be resprayed because of budworm reinfestations.

2/ Buckhorn, W. J. defoliator situation in the fir stands of eastern Oregon and Washington, season of 1947. U. S. Bur. Ent. and Plant Quar. Rpt. 13 pp., illus. (processed) February 18, 1948

3/ Eaton, C. B., Beal, J. A., Furniss, R. L., and Speers, C. F. airplane and helicopter spraying with DDT for spruce budworm control. Jour. Forestry 47: 823-827. 1949

7. Recovery of defoliated trees following spraying operations has been remarkable and has proved the program's value.

8. Valuable watersheds have been protected, and creation of a serious forest fire hazard has been largely averted.

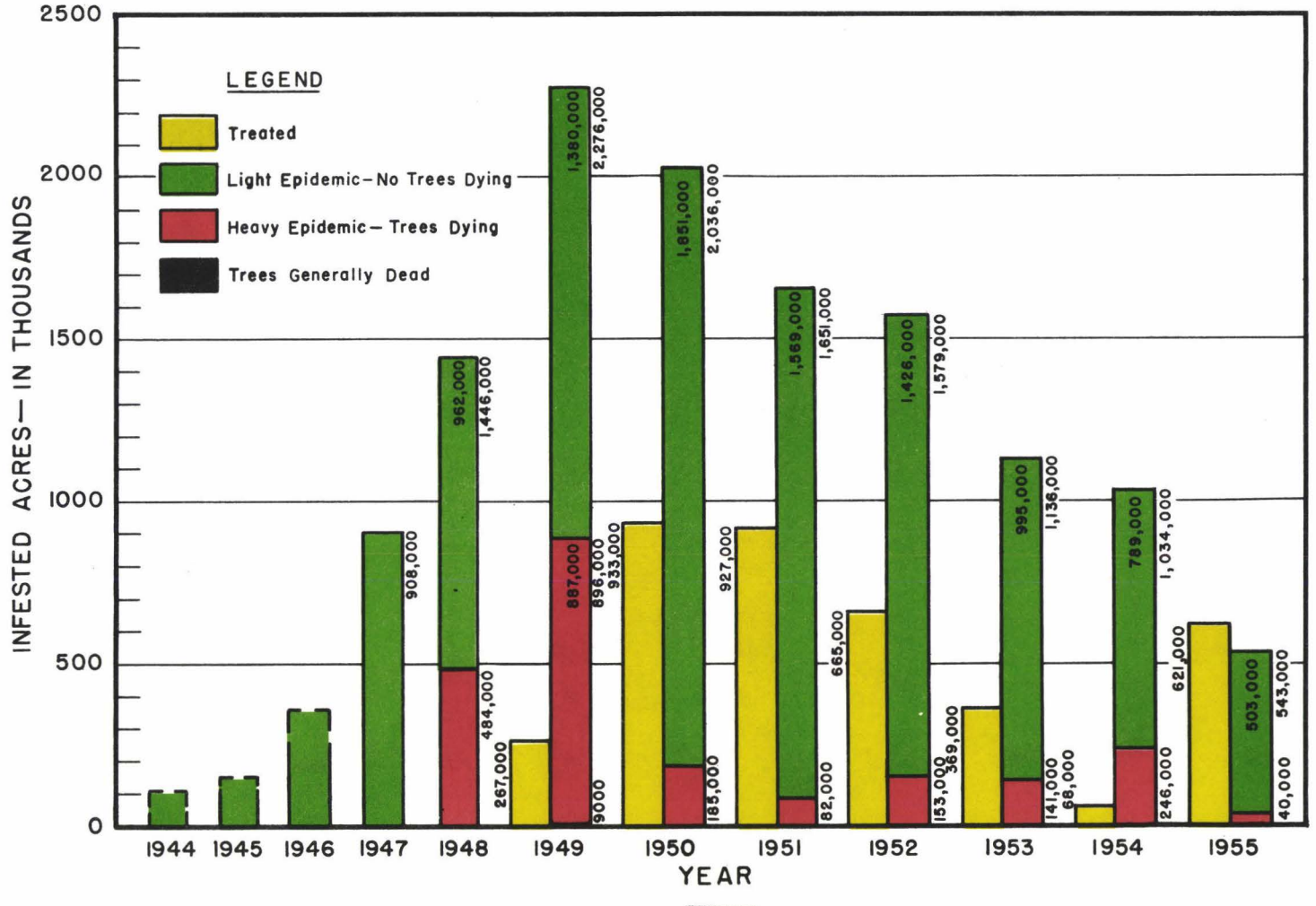
9. Practicability of aerial spraying to control the spruce budworm at a reasonable cost per acre has been fully demonstrated.

Table 1. --Mortality and cost of spraying, spruce budworm control program in Oregon and Washington, 1949-55

Year	Acres treated	Cost	Cost per acre	Mortality (percent) Range	Mortality (percent) Average
1949	266,234	$ 320,000	$ 1.20	88.9-100	97.6
1950	933,702	990,000	1.06	90.4-100	99.2
1951	926,729	983,000	1.06	74.0-100	98.6
1952	655,111	681,000	1.04	81.8-100	98.2
1953	369,171	350,000	.95	88.5-100	99.1
1954	67,717	63,000	.93	96.3-100	99.0
1955	620,947	658,000	1.06	79.0-100	96.9
Total	3,839,611	$4,045,000		74.0-100	
Average (wtd.)			$1.05		98.2

GRAPH I

PROGRESS OF SPRUCE BUDWORM EPIDEMIC IN OREGON AND WASHINGTON



1955 CONTROL PLANNING

Determination of Units to be Controlled in 1955

Cooperative aerial and ground surveys in 1954 [4/] recorded 1,034,440 acres of spruce budworm epidemic infestations, all in the Blue Mountain area of Oregon and Washington, divided as follows:

Washington	28,400 acres
Oregon	1,006,040 acres
Total	1,034,440

During the period October 4-7, 1954, a Spruce Budworm Subcommittee of the Northwest Forest Pest Action Committee, together with local representatives of private lumber companies and state and federal agencies, inspected areas of heaviest budworm damage reported by the survey. At the annual meeting of the Action Committee in Portland, Oreg., on November 1, 1954, survey findings and current status of the spruce budworm problem were thoroughly reviewed. The Committee recommended [5/] the following treatment of the infestation:

(1) Control should be undertaken in 1955 on six units totalling an estimated 600,720 acres in Oregon.

(2) Control on 85,300 acres should remain unscheduled pending survey findings in 1955.

(3) Control on 348,420 acres is not justified, largely because of low timber values.

(4) Administration of the 1955 project should be by the U. S. Forest Service and Oregon State Board of Forestry.

(5) Technical supervision of the 1955 project should be a responsibility of the Pacific Northwest Forest and Range Experiment Station.

4/ Oregon State Board of Forestry and Pacific Northwest Forest and Range Expt. Sta. report of forest insect surveys in Oregon and Washington, season of 1954., 50 pp., illus. (processed) November 30, 1954.

5/ Northwest Forest Pest Action Committee. spruce budworm control plan for 1955 in Oregon and Washington., 16 pp. (processed) November 1954.

In keeping with practices followed during preceding projects, final decisions as to necessity for control were delayed until information was obtained on the status of overwintering budworm populations on each proposed unit. Collections of limb samples containing overwintering 2nd instar larvae were made in November 1954 and February 1955, placed in rearing at Salem, Oregon and tabulations were made of larval emergence for each sample. (Details of this study are given on pages 33-5). This study showed that sufficient populations existed on each unit. As a result the Committee was advised that implementation of control plans was fully justified 6/.

On January 5, 1955 the Oregon State Board of Forestry, under requirements of Oregon Laws 527.340 (Oregon Insect and Disease Control Act), established zones of infestation containing the units to be treated. Descriptions of these zones appeared in newspapers published during the first week in April in Baker, Crook, Grand, Morrow, Union, and Wheeler Counties.

On April 19, 1955 the Governor of Oregon signed House Bill 597 authorizing $98,850 for the State's share of control costs. Formal notices were promptly mailed to all affected timberland owners. During May and early June, personnel of the Oregon State Board of Forestry contacted some 400 owners to explain the control project, reach an agreement on each owner's exact timbered acreage, and locate areas where precautions should be taken to avoid damaging crops or agricultural lands during spraying operations.

On May 6, 1955, the Forest Service regional office was advised that funds appropriated by Congress under provisions of Public Law 110 (Forest Pest Control Act), were available for budworm control in Oregon. Some $575,000 was allotted for the federal share of control costs.

Although original project planning was based on 600,720 acres, the final acreage treated was 620,947 (figure 1). This increase was brought about by two changes: (1) revision of original spray boundaries on each control unit and (2) inclusion of a large block of lightly-infested timber adjacent to the Ochoco Control Unit. The owner of this timber, Ochoco Lumber Company, wished to protect it against further budworm damage.

Project Organization

To conduct the 1955 project, the services of 213 persons (Roster of active participants in Appendix) were required. In addition, numerous map makers, radio technicians, and truck drivers played an important part in this undertaking.

6/ Whiteside, J. M. and A. G. Gruba. report of the emergence of overwintering spruce budworm larvae on units proposed for spraying during the 1955 Oregon spruce budworm control project. 5 pp. (processed) April 1955.

The stands to be treated during the 1955 project were divided into 6 control units. Administration of control work was divided as follows:

Agency	Control units	Acres treated
U. S. Forest Service	Malheur and Susanville	233,764
	Ochoco	233,730
	Total	467,494
Oregon State Board of Forestry	Powder River	84,583
	Eagle Creek	48,648
	Catherine Creek	20,222
	Total	153,453
	Project total	620,947

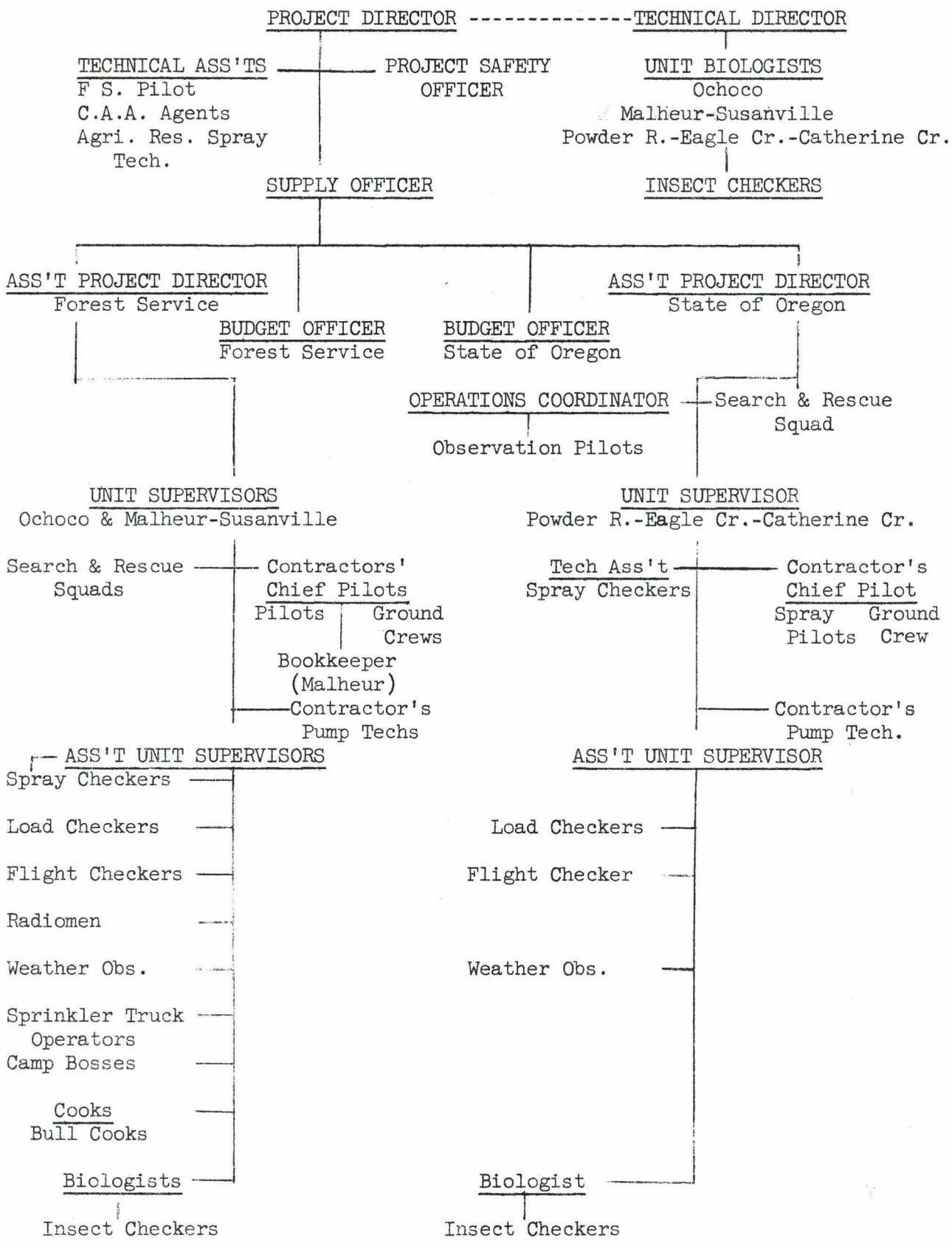
Project personnel were detailed from the Forest Service regional office, from the Malheur, Ochoco, and Wallowa-Whitman National Forests, and from the Oregon State Board of Forestry. Several persons were employed through the State Employment Office at Baker, for work on units treated by the State.

Technical direction of the project was again a responsibility of the Pacific Northwest Forest and Range Experiment Station 7/. Biologists and insect checkers were detailed from the Ochoco, Malheur and Wallowa-Whitman National Forests. One insect checker was furnished by the Oregon State Board of Forestry.

7/ Whiteside, J. M., plan for the technical direction of the 1955 Oregon spruce budworm control project. 21 pp., illus. (processed) April 1955.

The following personnel organization chart indicated project assignments:

PERSONNEL ORGANIZATION CHART



Bids for Materials and Services

As an economy measure, it was agreed that the Forest Service would prepare and issue all bids for insecticide; transportation, storage and pumping; and spraying. Bid invitations were prepared under the direction of Forest Service Region 6 Supply Officer F. Walisch with assistance from administrative and technical personnel. They were greatly improved over those of preceding projects. Awards were made to lowest qualifying bidders as follows:

Bid item	Contractor	Successful bid
Insecticide (Opened April 28)	Pennsylvania Salt Manufacturing Co.	$0.3195 per gal.
Transportation (Opened April 29)	Interstate Services, Inc.	0.13 per gal.
Spraying (Opened May 3)		
Malheur-Susanville Units	Livingston Aero Dusters	0.436 per acre
Powder River Unit	Bowler Air Service	0.438 per acre
Eagle Cr.-Catherine Cr. Units	Bowler Air Service	0.487 per acre
Ochoco Unit	Central Aircraft Co.	0.583 per acre

Formulated insecticide. Insecticide was again formulated in the following proportions: 1 pound of technical grade DDT to 1.25 quarts of an auxiliary hydrocarbon solvent and sufficient No. 2 fuel oil to make one gallon of solution at 60 degrees Fahrenheit. It was applied at a rate of 1 gallon per acre.

The chemical company successfully met contract requirements as follows:

200,000 gallons to be delivered at Portland not later than May 20.
200,000 gallons to be delivered at Portland not later than June 1.
Balance to be delivered at Portland not later than June 15.

A total of 628,379 gallons of insecticide was used on the project with payment made on a basis of volumes delivered at 60° F.

The cooperation of Dr. W. E. Westlake, Chemist, U.S.D.A. Agricultural Research Service, Yakima, Wash., was again secured to perform the following services: (1) test the ingredients used to formulate the insecticide and (2) analyze samples of each "lot" of 20,000 gallons of insecticide for amount of DDT per gallon.

A Forest Service employee, as a Government representative, witnessed collections by company chemists of "running pint samples" from each of 30 lots of insecticide formulated for the 1955 project. The company chemist kept one pint from each lot for independent analyses of DDT content. One pint from each lot was airmailed to Dr. Westlake for analysis and results were promptly telephoned to the Supply Officer, who, immediately notified the company chemists. If contract specifications were met, each lot was released to the transportation contractor. If specificiations were not met, additional DDT was added and another analysis made before release. Only once was reformulation necessary.

A summary of the analyses made by Dr. Westlake is as follows:

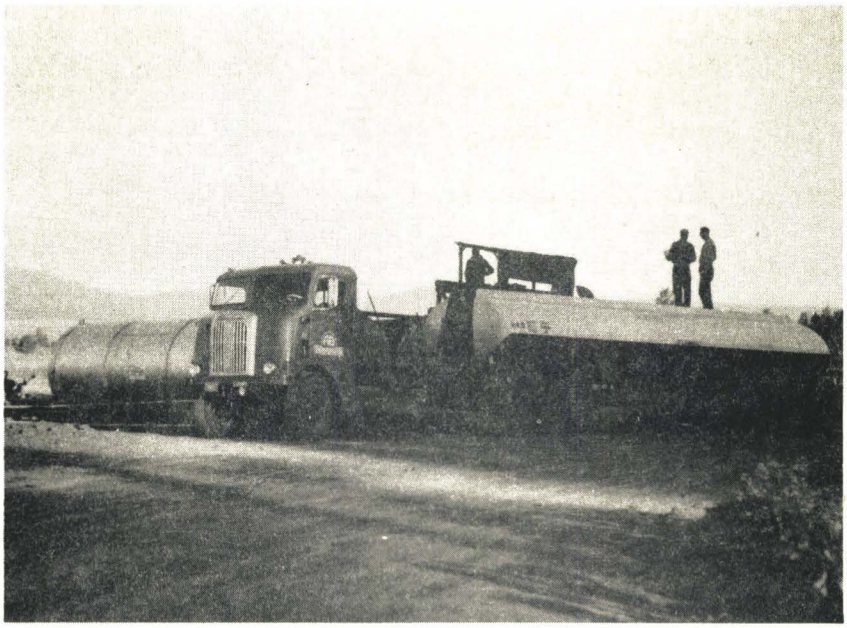
Lot No.	Pounds of DDT/Gallon	Lot No.	Pounds of DDT/Gallon
1	1.02	16	.99
2	1.01	17	1.00
3	1.01	18	1.00
4	1.00	19	.99
5	1.02	20	1.015
6	1.02	21 and 22	.995
7	1.01	23	1.01
8	1.01	24	1.01
9	1.00	25	1.01
10	1.00	26	1.02
11	1.00	27	1.00
12	.99	28	1.01
13	1.00	29	.999
14	.99	30	1.00
15	.98		
		Total	29.134
		Average	1.005

Each of the 30 lots was satisfactory. The lots which were only slightly below specifications were mixed in storage tanks with those above the 1-pound level. This mixing resulted in an insecticide containing slightly more than the required amount of DDT.

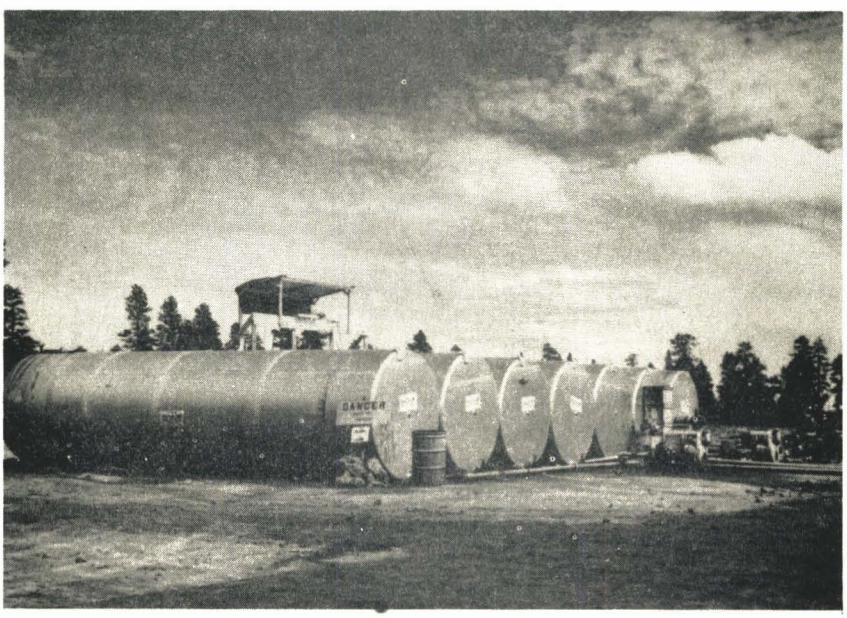
Insecticide transportation and storage. Early in May, the transportation contractor began trucking formulated insecticide by tank truck from the processing plant in Portland, Ore., to intermediate storage tanks at Madras and Pendleton, Ore. As soon as the 10,000 gallon storage tank facilities at the three airfields were in place, insecticide was trucked directly to the airfields (plate II). All airfield storage tanks were filled by June 10.

Upon completion of each day's operation, Unit Supervisors notified the contractor as to insecticide needs. All tanks were promptly filled. Often a tank truck was waiting at each airfield to refill storage tanks before operations stopped. Some minor difficulties with pumping facilities were encountered on the first day's operation but these were quickly corrected by the contractor's pump technician stationed at each airfield.

PLATE II. INSECTICIDE TRANSPORTATION AND STORAGE



Transport truck unloading DDT insecticide at Big Summit Airstrip, Ochoco Control Unit



10,000-gallon insecticide storage tanks and flight control tower at Big Summit Airstrip, Ochoco Control Unit

Aircraft. All aircraft were required to comply with Civil Aeronautics Administration directives and specifications, Civil Air Regulations, and pertinent laws and regulations of the State of Oregon. CAA Agents, Safety Advisor G. Douglas of the State of Oregon Board of Aeronautics, Forest Service Pilot M. Pierce, and State of Oregon Pilot A. Larsen, cooperated in inspecting planes for safety installations and spraying apparatus, and in checking pilot qualifications. Without doubt, these inspections were an important factor in another fine project safety record.

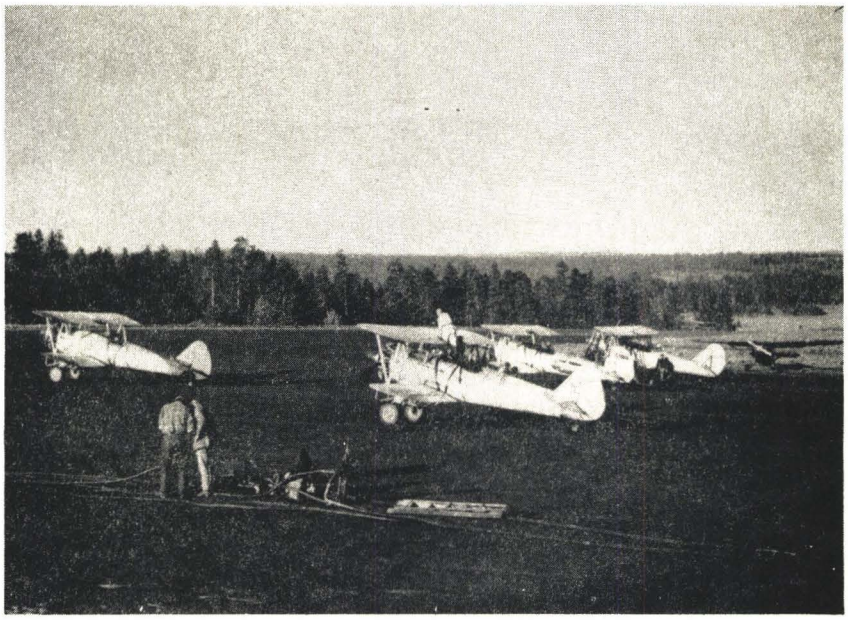
During this project, 69 airplanes (table 2) actively engaged in operational phases of control. There were 58 spray planes, of which 41 were Stearmans with 450 HP motors (plate III); 9 observation planes, 1 of which was the State of Oregon Cessna 170B used by pilot Larsen to inspect aircraft and pilots, check application of insecticide, and for personnel transportation; and 2 general use planes - 1 Forest Service Beechcraft Bonanza used by pilot Pierce for purposes similar to those of the State of Oregon plane, and 1 Navion owned by transportation contractor M. Lennington and used to shuttle between airfields to check storage tank and pumping facilities. Airplanes were also used by CAA personnel for prespray inspections of aircraft and pilots and for spot checks of compliance with regulations during operations.

Table 2--Number and type of aircraft used, 1955 Oregon spruce budworm control project

Aircraft	Ochoco unit	Malheur Susanville units	Powder River unit*	Eagle Creek unit*	Catherine Creek unit*	Total planes used on project*
Spray planes:						
Single Engine:						
Fairchild 71			2	1		2
Fokker Sup. Univ.				1		1
N3N	2	3	2	1		7
Stearman PT-17	17	20	3	2	1	41
Stinson SM 7A			1			1
TBM				1	2	2
Total	19	23	8	6	3	54
Multi-engine:						
Boeing 247	1					1
Ford Tri-motor (Large)			1	1		1
Ford Tri-motor (Small)			2	1		2
Total	1		3	2		4
Observation planes:						
Cessna 170		1	1	1	1	2
Piper Clipper			1	1	1	1
Piper Pacer		1				1
Piper Tri-Pacer		1	1	1	1	2
Stinson Voyager	3					3
Total	3	3	3	3	3	9
General-use planes:						
Beechcraft Bonanza	1	1				1
Navion	1	1	1	1	1	1
Total	2	2	1	1	1	2
All planes	25	28	15	12	7	69

* The N3N's, Stearman's, Ford tri-motor's, and observation planes were used interchangeably on these three units, and the general-use planes were used on all units. Therefore, the number of "operating planes" is larger than the number "used".

PLATE III. AIRCRAFT AT BIG SUMMIT AIRSTRIP, OCHOCO CONTROL UNIT



Stearman spray planes loading and taking off

Line of Stearman spray planes tied down after day's spraying

Airfields

It was necessary to construct and maintain two airstrips for the 1955 project at a cost of $19,240.56. To treat the Ochoco unit, a two-way airstrip was constructed on public land at Big Summit Prairie (figure 2). A similar strip was constructed on leased land at Fox Valley for treating the Malheur and Susanville units. Cost of the lease was $650. The Powder River, Eagle Creek, and Catherine Creek units were treated from Baker Municipal Airport.

Figure 2. Landing strip (right), loading strip (center), and take-off strip at Big Summit Airstrip, Ochoco Control Unit

Portions of landing, take-off, and loading strips at both airstrips were treated with sulfite lignin to stabilize the soil and settle dust. A manufacturing residue, this liquid was supplied without charge by Publishers Paper Company, Oregon City, Oreg. The Forest Service paid for transportation to the airstrips and for application. Some 70,260 gallons were used on the Fox Valley Airstrip and 93,310 gallons used on the Big Summit Airstrip. Where wheel traffic and prop blasts were heavy, two coats of fuel oil were applied over the sulfite.

Maps, Mosaics, and Photographs

Obtaining aerial photographs and preparing planimetric maps and mosaics, (figure 3) was a responsibility of Forest Service Region 6 Cartographic Section. The Oregon State Board of Forestry prepared base maps for units under its administration. Each control unit was divided into individual spray blocks to facilitate administration of aerial spraying. After deletions had been made for openings of more than 160 acres and for non-spray timber types, spray blocks varied in size from 373 to 8,383 acres. Spray block boundaries for Forest Service units were determined by unit supervisors and chief pilots; for State of Oregon units, they were determined by the unit supervisor and the operations coordinator.

Figure 3. Assistant Project Director Compton and Unit Supervisor McComb examining aerial mosaic of Eagle Creek Control Unit

Individual photographs of spray blocks mounted on one side of cardboard sheets with a corresponding planimetric map on the other side were provided for spray pilots. On the Malheur-Susanville Unit, nearly complete coverage by U.S.G.S. Quadrangle sheets was available. These sheets were used to good advantage by observation and spray pilots and other project personnel.

Communications

Telephone and shortwave VHF radio communication systems were established and maintained at each airfield for coordination of project activities. Full-time radio operators were on duty at Big Summit and Fox Valley airstrips during spraying operations. Radio messages at Baker Municipal Airport were handled by Assistant Unit Supervisor Crumb. All radio traffic was handled strictly in accordance with standard communication procedures.

During spraying operations, constant communication was maintained between unit headquarters and observation planes. Weather observers reported on fixed schedules until operations were shut down for the day. Some automobiles were also equipped with radio sets for communication with airfields.

A summary of types of radio equipment in operation on each control unit is as follows:

Location of Radio	Ochoco Unit	Malheur Susanville Units	Powder River Eagle Cr. Catherine Cr. Units
Unit headquarters	Pack set	Pack set	Elec. hdqt. set
Observation planes	Pack sets	Pack sets	Pack sets
Fixed weather stations	Lookout sets	Lookout sets	Handie-talkies
Mobile weather stations	Mobile 30 watt	Handie-talkies	Handie-talkies
Search and rescue squads	Handie-talkies	Handie-talkies	Handie-talkies
Operations coordinator			Multi-channel

CONTROL OPERATIONS

Safety

Safety in all project activities was strongly emphasized. To the late R. C. Lindberg, Forest Service Region 6 Safety Officer, goes much credit for another fine project safety record. Mr. Lindberg attended contract preparation meetings, reviewed contracts for safety features concerning flying and fire prevention, and visited the airstrips many times during control work. He was constantly alert for safety improvements.

Each Unit Supervisor prepared a detailed safety plan and a search-and-rescue plan covering aerial and ground operations. Frequent informal safety meetings were held by Unit Supervisors for all personnel. Temporary personnel were carefully instructed in proper driving techniques, accident prevention in the woods, and procedures in case of accident. Spray pilots were encouraged to take frequent rests, to reduce fatigue.

The several minor airplane accidents on the 1955 project were thoroughly investigated to determine causes and prevent reoccurrences. Complete reports were made.

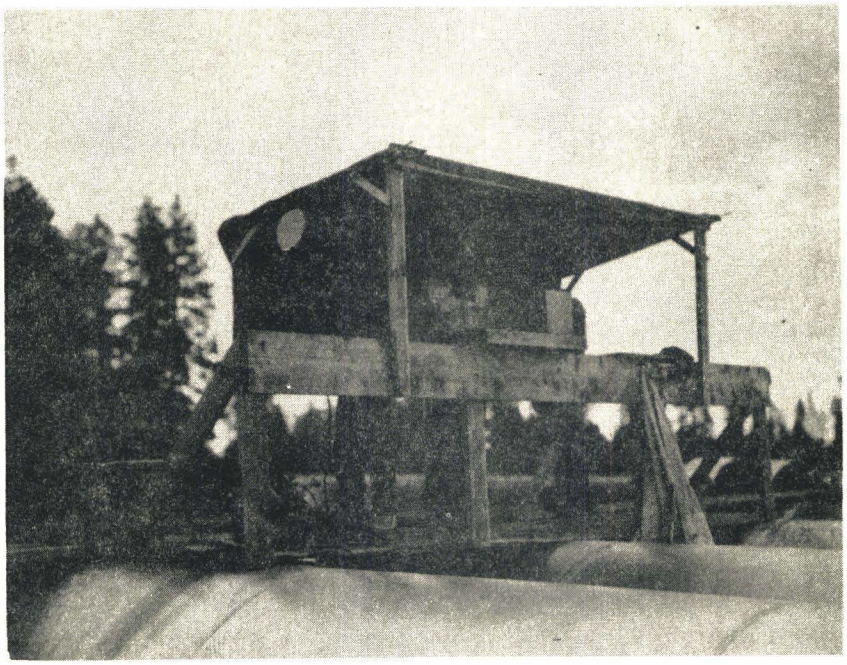
Only one serious accident occurred, resulting in hospitalization of a spray pilot. A lead pilot in a tandem spraying run, hit a tree top and crashed into a timbered hillside. The second pilot immediately dumped his load and returned to the airstrip to advise the Unit Supervisor of the crash location. The search-and-rescue plan was promptly activated. First aid was administered within 2 hours and the pilot was hospitalized less than 7 hours after the crash. This prompt action saved the pilot's life. The accident appeared avoidable since there was no evidence of engine failure.

Two safety features (plate IV) are worthy of special note:

1. Use of a "light gun" by the flight checker from a control tower constructed over insecticide storage tanks was very effective in directing take-off and landing of all aircraft at Big Summit Airstrip, Ochoco Control Unit. With 23 spray planes, 3 observation planes, and planes of supervisory and inspection personnel using this strip, such a system worked very smoothly. At other airfields, aircraft traffic followed predetermined patterns in an effective and safe manner. Strict records were kept by flight checkers at each airfield on time of take-off and arrival of all spray planes. Any unusual delay was promptly reported to the unit supervisor.

2. Tandem spraying of portions of the Malheur and Ochoco Control Units was employed as a safety measure in treating remote spray blocks that had long ferrying distances. It also facilitated treatment of blocks when larval development accelerated. This method paid dividends in the prompt rescue described above.

PLATE IV. SPECIAL SAFETY FEATURES OF 1955 PROJECT



Flight Checker Kinnard using "light gun" from traffic control tower to regulate aircraft landing and take-off at Big Summit Airstrip, Ochoco Control Unit

Tandem spraying was employed as a safety measure to expedite the treating of remote spray blocks

Aerial Spraying Operations

Spraying operations on the 1955 project began June 27 at 4:06 a.m. (official time of sunrise) at Baker Municipal Airport. They ended 25 days later on July 21 at 7:47 a.m. at the same airport. During this period there were only 4 non-spraying days, project-wide.

The starting and finishing dates for the 1955 project were not the earliest or latest for control operations in the Pacific Northwest. However, it is interesting to compare them with those of previous projects (table 3).

Table 3.--Duration of aerial spraying operations and areas treated, Oregon and Washington spruce budworm control program, 1949-1955

Year	Start	Finish	Duration	Area
			Days	Acres
1949	May 21 (Springfield)	June 20 (Wamic)	31	266,234
1950	May 24 (Roseburg)	July 16 (Walla Walla)	54	933,702
1951	May 24 (Roseburg)	July 8 (McKenzie)	46	926,729
1952	June 9 (Warm Springs)	July 18 (McKenzie)	40	655,111
1953	June 29 (Starkey)	July 27 (Santiam)	29	369,171
1954	June 25 (La Grande)	July 20 (La Grande)	26	67,717
1955	June 27 (Baker)	July 21 (Baker)	25	620,947

As shown by table 4, when operations were shut down on one or more control units they usually continued on other units. There were 4 reasons for curtailment or postponement of operations on individual units: (1) adverse weather - 14 days; (2) retarded larval and/or foliage development - 6 days; (3) contractor's request for postponement - 3 days; and (4) contract restrictions on number of days of consecutive aerial spraying - 1 day. No late afternoon or evening spraying was done on the project.

Table 4.--Daily spraying progress, by control units, 1955 Oregon spruce budworm control project

Date	Malheur Susanville unit	Ochoco unit	Powder River unit	Eagle Creek unit	Catherine Creek unit	Daily total	Cumulative total	Proportion completed
				Acres				Percent
June 27			5,892	3,776		9,668	9,668	1.6
28			(1/)	(1/)		0	9,668	1.6
29			(1/)	(1/)		0	9,668	1.6
30	26,390	7,343	7,280	5,460		46,473	56,141	9.0
July 1	9,640	10,240	100 1/	(1/)		19,980	76,121	12.3
2	24,493	7,440	6,695	8,292		46,920	123,041	19.8
3	(1/)	9,655	10,135	10,598		30,388	153,429	24.7
4	26,650	14,270	7,573	5,350		53,843	207,272	33.4
5	18,098	(4/)	(1/)	(1/)		18,098	225,370	36.3
6	(1/)	(4/)	(1/)	(1/)		0	225,370	36.3
7	6,500	(4/)	1/376	(1/)		6,876	232,246	37.4
8	1/ 2,220	2/4,653	6,558	2/2,154		15,585	247,831	39.9
9	(2/)	(1/)	2/1,032	486 1/		1,518	249,349	40.1
10	(2/)	(1/)	(1/)	(1/)		0	249,349	40.1
11	27,641	22,836	2/1,069	(2/)		51,546	300,895	48.4
12	20,024	12,303	2/2,043	(2/)		34,370	335,265	53.9
13	13,780	5,230 1/	800 1/	(2/)		19,810	355,075	57.2
14	14,950	20,538	2/2,449	1/915	2,001	40,853	395,928	63.7
15	23,927	23,879	100 1/	(1/)	(1/)	47,906	443,834	71.5
16	7,939	18,118	3,414	1/870	3,004	33,345	477,179	76.8
17	(3/)	24,971	5,000	4,484	3,655	38,110	515,289	83.0
18	11,512	22,732	4,825	1,644	3,045	43,758	559,047	90.1
19		21,174	6,798	2,014	3,686	33,672	592,719	95.4
20		8,348	6,751	1,565	3,476	20,140	612,859	98.7
21			5,693	1,040	1,355	8,088	620,947	100.0
Total	233,764	233,730	84,583	48,648	20,222	620,947	620,947	100.0
Av. per spray day	16,697	14,608	4,699	3,475	2,889	29,569		

1/ No spraying or limited spraying; adverse weather.
2/ No spraying or limited spraying; slow larval development.
3/ No spraying; contract restriction on consecutive spraying.
4/ No spraying; contractor requested shutdown.

Spraying operations were closely supervised on each unit. Observation pilots and project observers were in the air almost constantly checking behavior of spray patterns, completeness of coverage, safety precautions exhibited by pilots, and compliance with treating specifications.

Scheduled weather reports from fixed and mobile weather stations to the airfields were made at the following intervals: at 2:00 a.m., 3:00 a.m., 4:00 a.m. and 4:30 a.m. and then every 30 minutes until weather conditions began to approach the critical stages, when a 15-minute reporting interval was observed until shutdown.

Operations normally began at official time of sunrise at each airfield and continued until wind velocities reached 6 m.p.h. or temperatures reached 68 degrees F. Pilots often stopped spraying because of rough air over their spray blocks before these limitations were reached. In practically all cases, operations were shutdown for the day when observation pilots and project observers radioed that the spray pattern was beginning to "break up" and was not settling in a normal manner.

An average spraying day was about 4 or 5 hours from about 4 a.m. to about 8 or 9 a.m. Operations were often delayed until 5 or 6 a.m. due to strong winds or turbulent air over the blocks to be sprayed.

All spray planes and stand-by planes were carefully inspected and calibrated to insure maximum production. The amount of insecticide sprayed per minute by the various planes used ranged from 18 to 40 gallons for small planes and 55 to 160 gallons for large planes (table 5).

Table 5.--Basic performance data for spray planes, 1955 Oregon spruce budworm control project.

Aircraft type	Average spray load	Effective swath width	Optium spraying speed	Spray output per minute
	Gallons	Feet	M.P.H.	Gallons
Small planes				
Fairchild	161	200	100	40
Fokker	164	200	100	40
N-3-N	130	100	90-100	20
Stearman	130	100	90-100	20
Stinson	132	100	90	18
Large planes				
Boeing	545	400	180	160
TBM	586	400	140	113
Ford (large)	627	400	90-100	81
Ford (small)	465	300	85-90	55

A summary of aerial spraying operations by control units is given in table 6. A total of 3,992 flights for 293.24 hours of spraying time were made. Large planes (Boeing, Fords, and TBM) made 243 flights and small planes made 3,749 flights. Output of insecticide ranged from 376 to 53,843 gallons per spraying day, averaging 29,568 gallons per day. There were 2 days on the Powder River Unit when partial loads of 100 gallons of insecticide were applied to test spray behavior under early morning marginal weather conditions. Operations were promptly cancelled for these two days because of unsatisfactory spray patterns.

At the end of each spraying day, all planes received carefull inspections by certified mechanics. All repairs and adjustments were quickly made. Often mechanics worked all night to get spray planes ready for operations for following day. The excellent work of the ground crews played an important part in the success and safety record of this project.

Table 6.--Summary of aerial spraying operations, by control units, 1955 Oregon spruce budworm control project

Operation	Ochoco unit	Malheur Susanville units	Powder River unit	Eagle Creek unit	Catherine Creek unit	Project total
1. Spraying period	6/30-7/20	6/30-7/18	6/27-7/21	6/27-7/21	7/14-7/21	6/27-7/21
2. No. of spraying days	16	14	18	14	7	21
3. No. of non-spraying days	5	5	7	11	1	4
4. No. of operating spray planes	20	23	10	7	3	58
5. Total flights, large planes	70	0	85	53	35	243
6. Total flights, small planes	1,483	1,799	351	113	3	3,749
7. Total flights, all planes	1,553	1,799	436	166	38	3,992
8. Total flying time 1/	87.33	59.25	68.75	55.25	22.25	292.83
9. Total gallons sprayed	233,730	233,764	84,583	48,648	20,222	620,947
10. Gallons sprayed per hour	2,676.40	3,945.38	1,230.30	880.50	908.85	2,120.50
11. Least gallonage per day	4,653	2,220	376	486	1,355	376
12. Most gallonage per day	23,879	27,641	10,135	10,598	3,686	53,843
13. Average gallonage per day	14,608	16,697	4,229	3,475	2,889	29,568

1/ Total hours and minutes between daily departure of first spray plane and landing of last spray plane.

Checking Spray Deposits

One or two days before spraying, Unit Spray Checkers operating from each airfield put 4x5 dye-treated cards in the blocks to be sprayed (plate V). Placed 330 feet apart along compass lines at right angles to predetermined flight lines, these cards were used as a check on spray coverage. They were carefully examined immediately following spraying so that droplet size and uniformity of spray distribution could be determined. If several cards on a given line were untouched by spray and Biologists found little larval mortality in the immediate vicinity, contractors were required to respray that portion of the block. In general, spray coverage was good and there were few instances where respraying was necessary. These spray card lines, together with data on budworm mortality obtained from mortality lines, and spot checks, gave a satisfactory evaluation of insecticide application and coverage.

Spray coverage on over 70 percent of all spray blocks on the 6 control units was sampled in this manner (table 7).

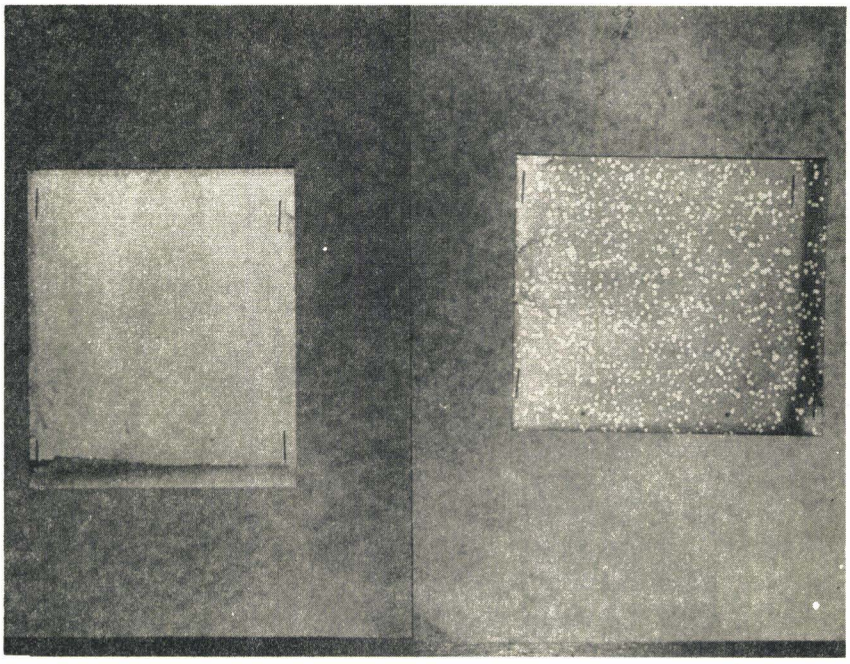
Table 7.--Samples taken to check spray deposits, by control units, 1955 Oregon spruce budworm control project.

Control unit	Spray blocks established	Spray blocks sampled	Spray cards per unit	Proportion of blocks sampled
	Number	Number	Number	Number
Catherine Creek	8	6	59	75.0
Eagle Creek	20	10	96	50.0
Powder River	34	19	190	55.9
Ochoco	83	70	646	84.3
Malheur-Susanville	93	63	454	67.7
Total	238	168	1,445	
Average (wtd.)				70.6

Dye-treated cards were used in preference to 4-inch-square glass plates used on previous projects. To overcome curling during damp weather, cards were stapled to 8x10-inch sheets of heavy paper. The papers were held in place by rocks on each corner. Cards left out for several days faded badly but spray deposits could be determined by immersing them in water. Considerable difficulty was encountered with small mammals chewing the dyed cards. As a result, a few cards on several lines were rendered useless. When this occurred, observations of spray coverage were made on broad-leaved plants and pools of water and branches checked for presence of budworm larvae.

PLATE V. CHECKS OF SPRAY DEPOSIT

Spray Checker Beck establishing compass line of dye-treated cards to check spray deposit. Cards were mounted on heavy sheets of paper to overcome curling



4x5 dye-treated cards used to check spray deposit
Before spraying (left) After spraying (right)

BIOLOGICAL INVESTIGATIONS

Forced Emergence of Overwintering Larvae

As previously mentioned a vital consideration in spruce budworm control planning is the status of overwintering larvae. It is necessary to know:

(1) Whether epidemic populations exist on proposed control units following egg-laying and hibernation periods.

(2) whether natural control factors such as low winter temperatures, parasites, etc., have reduced overwintering populations to a point where control measures are unnecessary.

To obtain answers to these questions, forced rearings have been made each year since 1949 from sample collections of limbs containing hibernating larvae. Collections are made at several points in each proposed unit.

At each collection point, 15 rough-barked limbs, 15 inches long are cut from each of 5 trees showing evidence of budworm defoliation. Limbs from each tree are placed in a box, which is then sealed and taken with other sample boxes to a central headquarters where they are all kept in light, heated rooms. Separate collections are made daily when larvae emerge from the boxes.

For previous projects, limb samples were collected in February and March. This involved a great deal of effort on the part of collectors, who snowshoed or skied to points deep in each unit and packed limb samples back to a car. A collection of limbs at each point weighed between 50 and 80 pounds and as much as 2-1/2 tons of limbs were handled in this manner for a single project.

Collection procedures were altered for the 1955 project as follows:

1. Sample limb collections were made late in November 1954 before roads were blocked by snow.

2. Limb samples were brought to accessible locations and stored out-of-doors at Baker Ranger Station, Raddue Guard Station, and Ochoco Ranger Station. The ends of all limbs were dipped in melted paraffin to prevent drying.

3. Early in February 1955, the entire collection was brought to the headquarters of the Oregon State Forester in Salem and placed in sealed 5-gallon ice cream containers for rearing.

In February, prior to moving the collection to Salem, comparable limb samples were cut from the same or adjacent trees at each of three spots sampled the previous November. This was done to compare larval emergence. It was found that November samples gave satisfactory data on overwintering budworm populations.

Table 8.--Larval emergence in forced rearing studies, by control unit and indicated collection month, 1955 Oregon spruce budworm control project

Control unit	Number of collection spots	Number of boxes	Number of limb samples	Total sq. in of bark area	Total larval emergence	Emergence per 100 sq. in. of bark area
NOVEMBER COLLECTIONS						
Ochoco	3	15	225	13,694.55	1,284	9.36
Malheur	4	20	300	17,117.47	858	5.01
Susanville	1	5	75	4,658.43	759	16.29
Powder River	4	20	300	19,209.26	1,235	6.43
Catherine Creek	1	5	75	4,497.14	62	1.38
Eagle Creek	2	10	150	9,779.00	156	1.60
Total	15	75	1,125	68,955.85	4,354	
Average (wtd.)						6.31
FEBRUARY COLLECTIONS						
Ochoco	1	5	75	4,663.16	352	7.53
Malheur	1	5	75	4,287.20	213	4.97
Powder River	1	5	75	4,380.95	356	8.13
Total	3	15	225	13,331.31	921	
Average (wtd.)						6.91
Total	18	90	1,350	82,287.16	5,275	
Average (wtd.)						6.41

When larval emergence from the rearing boxes was finished, the total square inches of bark area for each limb sample was measured and larval emergence computed per 100 square inches of bark area 7/ (table 8).

These studies showed that budworm populations on units proposed for treatment had not been reduced by natural enemies or low winter temperatures. Continuation of control plans, therefore, was believed justified and the Action Committee and control planners were so notified.

Spruce Budworm Larval Development

Three Biologists reported for duty May 9 and after one week's instruction and training began work on their assigned control units. They were returned to their regular assignments on July 30. Six Insect Checkers reported for duty by June 13 and were instructed by the Biologists as to their duties and assignments. These men remained on the project until about July 25.

A noticeably late seasonal development of grasses, plants, and trees occurred throughout the Blue Mountain region in 1955. The first needle mining by 2nd instar larvae (figure 4), was observed on May 19, indicating

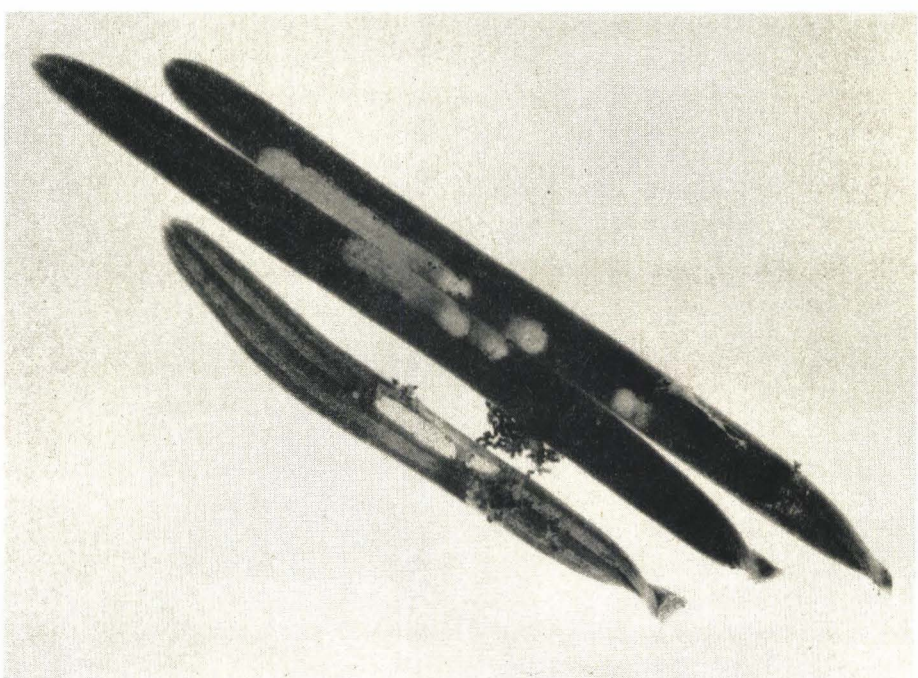


Figure 4. Evidenee of needle mining by 2nd instar spruce budworm larvae

7/ Collections and measurements of limb samples and daily collections of emerging larvae were made by A. G. Gruba and D. Sheridan of the Oregon State Board of Forestry.

that overwintering larvae had started to break hibernation. As late as May 27 there was little evidence of swelling of fir buds at low elevations on any control unit. Nights remained cold during most of May and June. It was not until after July 9 that temperatures rose sufficiently to accelerate larval development over large portions of all units.

The following notes on budworm development and spraying operations sum up salient features of the 1955 project:

Event	Date	Days from time needle mining first observed
Budworm development:		
Needle mining first observed	May 19	
First 4th instar larva collected	June 7	19
First 5th instar larva collected	9	21
First 6th instar larva collected	20	32
First pupa collected	July 12	54
First emerged pupal case collected	26	68
Control Activities:		
First mortality lines established	June 25	37
Start of spraying operations	27	39
End of spraying operations	July 21	63
Last mortality line examined	30	72

RESULTS OF THE 1955 PROJECT

Assessment of Spruce Budworm Mortality

Some of the constant perplexities of a budworm control project are the prediction and establishment of dates for starting and sequence of spraying operations. Cold days and nights during May and most of June greatly retarded larval and foliage development in 1955, making predictions of spraying dates most difficult. The uneven development of larvae and foliage caused many technical problems and resulted in excessive splitting of spray blocks. On white fir, new growth would be 1 to 2 inches long while buds on adjacent Douglas-fir would be only partially swollen. Budworm larvae in the 4th, 5th, and 6th instars would be found in both stages of foliage development. As a result, portions of blocks or entire spray blocks were usually not released for spraying until a high percentage of 6th instar larvae was present. A comparison of budworm distribution by stages before and after spraying is given by control units in table 9.

Method of Obtaining Mortality Data

One of two days before spraying, technical personnel installed mortality lines at right angles to flight lines in blocks released for treatment. In several blocks mortality lines were installed just before pilots began treating the blocks. On some other blocks, rather than lose time in field examinations, sample branch tips were taken to camp in ice cream cartons and examined that night in order to have lines established before spraying the next day.

Each mortality line consisted of 10 sampling stations, 330 feet apart if established along trails or across the block , or 0.2 miles apart if along roads. However, a few lines contained less than 10 stations because of timber type or topography.

At each station, 10 branches 15-inches long (2 from each of 5 trees) were carefully clipped over a collecting cloth and all budworm larvae or pupae counted and recorded (plate VI). The first 100 larvae on each line were preserved in alcohol to determine final larval instar development prior to spraying.

Ten days after spraying, the lines were rerun. At each station, the sample was doubled and 20 branches 15 inches long (4 from each of 5 trees) were clipped over a cloth and carefully examined for surviving larvae, pupae, or emerged pupal cases. The number of days between spraying and post-spray checks ranged from 9 to 15 and averaged 10.2 days.

Mortality lines were established in 80 (33.6%) of the 238 spray blocks in the 6 control units. On these 80 lines, 754 sampling stations were tagged for examination before and after spraying (table 10).

Table 9.--Budworm development classes before and after spraying, 1955 Oregon spruce budworm control projects

Control unit	Relation to spraying period	Budworms collected (Number)	Percent of Total Collections							
			Larval instars					Pupae	Emerged pupae	Total
			2	3	4	5	6			
Ochoco	Before	3,000	0	0.4	29.0	57.5	13.1	0	0	100
	After	1,415	0	0	23.7	41.6	30.5	4.2	0	100
Malheur	Before	1,800	0	.2	33.5	53.9	12.4	0	0	100
	After	589	0	0	23.8	45.4	78.6	2.5	0	100
Susanville	Before	300	0	0	10.3	48.7	41.0	0	0	100
	After	84	0	0	7.2	19.0	27.4	1/46.4	0	100
Powder River	Before	1,772	0	.8	28.7	49.9	20.0	0.6	0	100
	After	2/ 187	0	0	12.3	28.3	26.7	24.6	8.1	100
Eagle Creek	Before	700	0	.6	34.0	58.6	6.8	0	0	100
	After	194	0	0	18.0	35.1	40.7	6.2	0	100
Catherine Cr.	Before	400	0	.5	14.5	70.5	14.5	0	0	100
	After	3	0	0	0	0	33.3	66.7	0	100
Total	Before	7,962	0	0.4	29.0	55.5	15.0	0.1	0.0	100
	After	2/ 2,472	0	0	22.3	40.1	30.6	6.4	0.6	100

1/ All pupae found on this unit after spraying were on 2 blocks added near the end of operations. When spraying started, 78% of the larvae were in the 6th instar and marginal control was anticipated. However, overall control of the budworm on the Susanville unit was good (97.9%).

2/ All surviving larvae were not saved so these totals do not agree with corresponding figures in table 11.

PLATE VI. ACTIVITIES OF INSECT CHECKERS

Insect Checker Rensil clipping 15-inch branches to determine budworm population surviving spraying

Insect Checkers Wise and Rensil examining 15-inch branches for surviving budworm larvae

Table 10.--Samples taken to check budworm mortality, by control units, 1955 Oregon spruce budworm control project

Control Unit	Spray blocks	Mortality lines established	Sampling stations	Proportion of blocks sampled
	Number	Number	Number	Percent
Catherine Creek	8	4	40	50.0
Eagle Creek	20	7	62	35.0
Powder River	34	18	153	52.9
Ochoco	83	30	300	36.1
Malheur-Susanville	93	21	199	22.6
Total	238	80	754	
Average (wtd.)				33.6

In addition to mortality lines, general observations and spot checks were made throughout each unit by technical personnel to determine overall results of spraying. These checks substantiated findings on mortality lines.

Spruce Budworm Mortality

In order to rate and compare control results, standards were established early in the program as follows:

Excellent control	(98-100%)	: Project average should fall in this range.
Good control	(95-97%)	: Acceptable for blocks and occasional units.
Marginal control	(90-94%)	: Acceptable for occasional blocks but not for units.
Poor control	(Below 90%)	: Unsatisfactory; respraying probably necessary.

A goal of 100 percent control on all blocks, units, and projects is most desirable but difficult to attain. Practical goals on each project have been to reduce budworm populations to the lowest possible level, in order to protect treated stands for the longest possible period.

On the 1955 project, spruce budworm mortality ranged from 79.0 to 100 percent on individual spray blocks and units and averaged 96.9 percent for the entire project (table 11).

Table 11.--Budworm mortality by control units, 1955 Oregon spruce budworm control projects

Control unit	Larvae or pupae on mortality lines		Mortality	
	Before spraying	After spraying	Range	Average
	Number	Number	Percent	Percent
Catherine Creek	1,514	3	99.0-100.0	99.8
Susanville	4,010	84	93.0-99.2	97.9
Powder River	13,442	331	82.1-100.0	97.5
Malheur	22,446	589	79.0-100.0	97.4
Ochoco	38,566	1,415	81.9- 99.9	96.3
Eagle Creek	4,266	194	89.3-100.0	95.6
Total	84,244	2,616	79.0-100.0	
Average (wtd.)				96.9

Prior to spraying, only 2 budworm pupae were found. Of 2,616 budworm collected after spraying, 15 were emerged pupae, 117 were unemerged pupae, and 2,424 were larvae.

A summary of budworm mortality for each mortality line on the 6 control units is presented in table 12 in the Appendix.

Natural Control

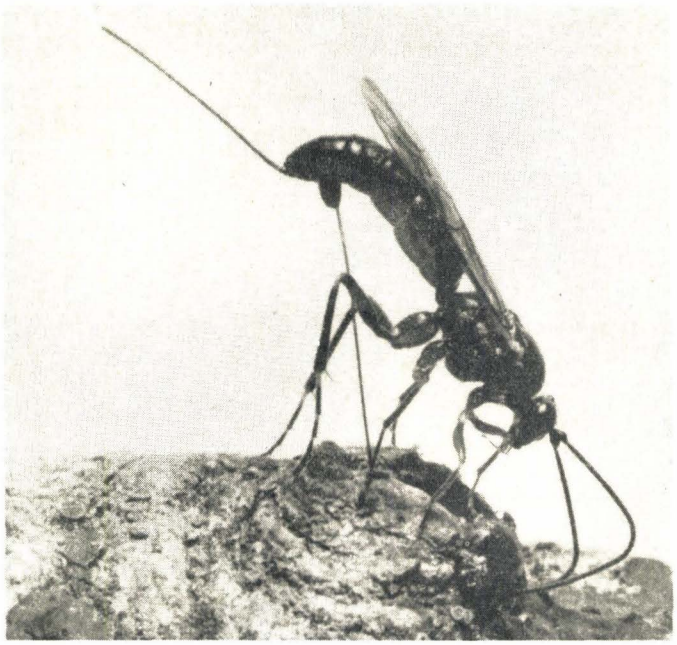
Spruce budworms surviving aerial spraying operations represent a potential source of reinfestation to units brought under control. Because of attacks by parasites, the number of surviving budworm reaching maturity is often reduced. Examples of budworm parasites are shown in plate VII.

To obtain data on parasite effectiveness among budworms surviving control operations in 1955, samples of larvae from post-spray collections on each unit, except Catherine Creek, were dissected 8/. Since only 3 surviving larvae were obtained from post-spray collections on the Catherine Creek unit, which showed a 99.8 percent kill, determination of parasites was not made.

Of 978 larvae dissected, 422 (43.2%) were found to have been attacked by 5 species of parasites: Apanteles sp., Glypta sp., Omotoma sp., Horogenes sp., and Lypha sp. The first species was recovered from 374 of the 422 larvae dissected. A summary of parasites recovered from 4th, 5th, and 6th instar larvae on each control unit is given in table 13.

8/ Dissections were made by P. W. Orr and V. M. Carolin.

PLATE VII. NATURAL ENEMIES OF THE SPRUCE BUDWORM



Glypta fumiferanae (Vier.)
Adult ovipositing in overwintering budworm larva under bark scale

Phytodietus fumiferanae Rohw.

External hymenopterous budworm parasite

Actia interrupta Curran

Puparium of larvaevorid budworm parasite

Table 13.--Species and number of parasites dissected from budworm larvae surviving spraying, 1955 Oregon spruce budworm control project

Control unit	Surviving larvae dissected			Parasite species found and proportion of larvae parasitized										Total parasites found and larvae parasitized	
		Apanteles		Glypta		Omotoma		Horogenes		Lypha					
	Instar	Number	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent		Number	Percent
Powder River	4	5	5	100.0										5	100.0
	5	128	79	61.7	8	6.3			1	0.8				88	68.8
	6	51			1	2.0								1	2.0
Total and Average (wtd.)		184	84	45.7	9	4.9			1	0.5				94	51.1
Malheur	4	15	5	33.3										5	33.3
	5	134	90	67.2	3	2.2								93	69.4
	6	60	3	5.0	4	6.7								7	11.7
Total and Average (wtd.)		209	98	46.9	7	3.3								105	50.2
Eagle Creek	4	11	10	90.9	1	9.1								11	100.0
	5	53	32	60.4										32	60.4
	6	32	1	3.1										1	3.1
Total and Average (wtd.)		96	43	44.8	1	9.1								44	45.8
Ochoco	4	79	43	54.4	2	2.5								45	56.9
	5	260	100	38.5	22	8.5					1	0.4		123	47.3
	6	121			1	8.3								1	8.3
Total and Average (wtd.)		460	143	31.1	25	5.4					1	0.2		169	36.7
Susanville	4														
	5	12	6	50.0	2	16.7								8	66.7
	6	17					2	11.8						2	11.8
Total and Average (wtd.)		29	6	20.7	2	6.9	2	6.9						10	34.5
All units	4	110	63	57.3	2	2.7								66	60.0
	5	587	307	52.3	35	5.9			1	0.2	1	0.2		344	58.6
	6	281	4	1.4	6	2.1	2	0.7						12	4.2
Total and Average (wtd.)		978	374	38.2	44	4.5	2	0.2	1	0.1	1	0.1		422	43.2

Parasitism of surviving larvae was heaviest in the 4th and 5th instars and on the Powder River and Malheur units, as shown by table 14.

Table 14.--Parasitism in budworm larvae surviving aerial spraying, 1955 Oregon spruce budworm control project.

Control unit	Surviving larvae sampled and proportion parasitized (by larval instars)						Total budworm sampled	Average proportion parasitized (wtd.)
	4th		5th		6th			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Susanville	0	00.0	12	66.7	17	11.8	29	34.5
Ochoco	79	57.0	260	47.3	121	8.3	460	36.7
Eagle Creek	11	100.0	53	60.4	32	3.1	96	45.8
Malheur	15	33.3	134	69.4	60	11.7	209	50.2
Powder River	5	100.0	128	69.8	51	2.0	184	51.1
Total	110		587		281		978	
Average (wtd.)		60.0		58.6		4.3		43.2

Budworm mortality resulting from control operations was found to be 96.9 percent. If 43.2 percent of the surviving budworms were parasitized, then the combined reduction in budworm populations from these two causes on the 6 control units was 98.2 percent 9/.

A more significant interpretation of reductions in budworm populations on the 6 control units would be obtained if parasitism of budworm larvae before spraying had been computed. However, only 100 larvae on each mortality line were preserved for determinations of larval stages prior to spraying. Unfortunately these samples were not saved for dissection.

9/ The following formula was used to obtain this figure:

$$\frac{\text{Budworm before spraying} - (\text{Budworm after spraying} - \text{Budworm parasitized})}{\text{Budworm before spraying}} =$$

$$\frac{84{,}244 - (2{,}616 - 1{,}130)}{84{,}244} \times 100 = 98.2\%$$

Project Costs

Project costs were apportioned in accordance with a formula recommended by the Northwest Forest Pest Action Committee since 1951 as follows:

Federal government: 100 percent of control costs on federal lands
25 percent of control costs on private lands

State of Oregon: 100 percent of control costs on state, county, and municipal lands
37.5 percent of control costs on private lands

Private land owners: 37.5 percent of control costs on private lands

For the 1955 project, almost 81 percent of the total area sprayed was federally owned (table 15).

Table 15.--Acreage sprayed by ownership classes and control units, 1955 Oregon spruce budworm control project

Control units	Federal	Private	State, county and municipal	Total
	Acres	Acres	Acres	Acres
Malheur-Susanville	172,866	60,311	587	233,764
Ochoco	204,167	29,501	62	233,730
Powder River	61,113	22,891	579	84,583
Catherine Cr.-Eagle Cr.	64,448	4,422	0	68,870
Total	502,594	117,125	1,228	620,947

Total cost of treatment was $658,060.27, or $1.0598 per acre (table 16). The distribution of control costs by major items was as follows:

Item	Total cost	Cost per acre	Percent of total cost
Aerial spraying	$308,772.73	$0.4973	46.9
Formulated insecticide	197,055.15	.3173	30.0
Insecticide transportation, and pumping facilities	80,781.58	.1301	12.3
Airstrip construction and maintenance	19,240.56	.0310	2.9
Other (Salaries, subsistence, maps, mosaics, photos, equipment, transportation, etc.)	52,210.25	.0841	7.9
Total	$658,060.27	$1.0598	100.0

Table 16.--Costs of the 1955 Oregon spruce budworm control project

	Forest Service			State of Oregon				
	Ochoco unit	Susanville Malheur units	Total	Catherine Cr. Eagle Cr. units	Powder River unit	Total	Project total	Cost per acre
Aerial spraying	$136,264.59	$101,921.10	$238,185.69	$33,539.69	$37,047.35	$70,587.04	$308,772.73	$0.4973
Insecticide	74,270.04	74,086.00	148,356.04	21,856,25	26,842.86	48,699.11	197,055.15	.3173
Transportation, pumping, storage	28,860.36	30,216.52	59,076.88	9,741.08	11,963.62	21,704.70	80,781.58	.1301
Airstrip construction and maintenance	11,537.76	7,702.80	19,240.56	---	---	---	19,240.56	.0310
Equipment purchase and rental	4,717.62	1,150.00	5,867.62	672.37	825.82	1,498.19	7,365.81	.0119
Maps, mosaics, photos	1,497.19	1,486.97	2,984.16	441.47	542.44	983.91	3,968.07	.0064
Salaries, subsistence, transportation, misc.	19,439.65	15,700.00	35,139.65	3,077.82	2,658.90	5,736.72	40,876.37	.0658
Total	276,587.21	232,263.39	508,850.60	69,328.68	79,880.99	149,209.67	658,060.27	1.0598
Cost per acre	1.1834	0.9936	1.0885	1.0066	0.9444	0.9723	1.0598	

Distribution of control expenditures among landowners and land managing agencies was as follows:

	Cost	Percent of total
Private landowners	$ 37,244.01	5.7
State of Oregon	51,810.36	7.8
Federal government	569,005.90	86.5
Total	$ 658,060.27	100.0

EVALUATION OF THE 1955 PROJECT

Each of the seven spruce budworm control projects since 1949 has had three common, unpredictable factors affecting the scheduling and completion of spraying operations. These are: (1) uneven development of spruce budworm larvae, (2) uneven development of new foliage of Douglas-fir and true fir, and (3) temperature and wind variations over spray blocks and units. Effects of these factors on completion of the 1955 project were pronounced.

Spraying operations on each unit began at low elevations and on south exposures where larval and foliage development was most advanced. Since practically all spray-block boundaries were originally established along easily recognized topographic features, it was often necessary to split blocks several times in order to treat portions ready for spraying. As shown in table 3, operations were postponed several times on each unit because of slow larval development. The Catherine Creek Unit was the latest to develop and operations could not be started on this unit until July 14. On both the Eagle Creek and Powder River Units, larval development progressed very slowly and on several days operations were limited to one or two planes due to a lack of blocks ready for spraying. The Malheur and Susanville Units had the least number of operational interruptions. As expected, a few warm days and nights greatly accelerated larval and foliage development. However, many blocks could not be entirely released for treatment until mid-July.

The number of days elapsing between block release and start of spraying ranged from 1 to 10 and averaged about 2. Unit Supervisors are to be commended for the the efficient manner in which spraying operations were scheduled and completed. Operations Coordinator Larsen and the chief pilots on all units deserve much credit for the excellent manner in which individual blocks were assigned and boundaries shown to spray pilots. Upon completion of one block a pilot often started another the same day, thereby avoiding serious operational delay.

Respraying of portions of blocks was necessary in only five instances. This is remarkable in view of the extensive spray block splitting required for success of the project.

Throughout the project, every precaution was taken to avoid damage to agricultural lands, crops, and fish. No reports of damage of any kind have been received.

Table 12.--Summary of mortality sampling, by control units, 1955 Oregon spruce budworm control project

Spray block number	Number of samples: Lines	Stations	Population before spraying: Larvae	Pupae	Total	Total 2x*	Population after spraying: Larvae	Pupae	Emerged pupae	Total	Mortality percent
MALHEUR CONTROL UNIT											
42	1	10	635	0	635	1,270	0	0	0	0	100.0
23	1	10	534	0	534	1,068	0	0	0	0	100.0
28	1	10	790	0	790	1,580	2	0	0	2	99.9
88	1	10	502	0	502	1,004	3	0	0	3	99.7
46	1	10	685	0	685	1,370	4	0	0	4	99.7
65	1	7	391	0	391	782	3	0	0	3	99.6
66	1	7	310	0	310	620	5	0	0	5	99.2
29	1	8	366	0	366	732	6	0	0	6	99.2
43	1	10	651	0	651	1,302	12	0	0	12	99.1
83	1	10	458	0	458	916	8	1	0	9	99.0
55	1	10	953	0	953	1,906	25	0	0	25	98.7
15	1	10	755	0	755	1,510	21	1	0	22	98.5
39	1	8	360	0	360	720	8	5	0	13	98.2
37	1	10	599	0	599	1,198	21	3	0	24	98.0
72	1	10	495	0	495	990	22	0	0	22	97.8
74	1	10	1,475	0	1,475	2,950	115	0	0	115	96.1
47	1	9	622	0	622	1,244	49	5	0	54	95.7
78	1	10	642	0	642	1,284	270	0	0	270	79.0
Total	18	169	11,223	0	11,223	22,446	574	15	0	589	97.4
SUSANVILLE CONTROL UNIT											
9	1	10	862	0	862	1,724	13	0	0	13	99.2
7	1	10	793	0	793	1,586	22	0	0	22	98.6
94	1	10	350	0	350	700	10	39	0	49	93.0
Total	3	30	2,005	0	2,005	4,010	45	39	0	84	97.9

*Twice the number of branches were sampled after spraying to determine mortality. Therefore, the number of larvae collected before spraying has been multiplied by two.

Table 12 (cont.)--Summary of mortality sampling, by control units, 1955 Oregon spruce budworm control project

Spray block number	Number of samples: Lines	Number of samples: Stations	Population before spraying: Larvae	Population before spraying: Pupae	Population before spraying: Total	Population before spraying: Total 2x	Population after spraying: Larvae	Population after spraying: Pupae	Population after spraying: Emerged pupae	Population after spraying: Total	Mortality percent
OCHOCO CONTROL UNIT											
43	1	10	790	0	790	1,580	1	0	0	1	99.9
28	1	10	502	0	502	1,004	2	1	0	3	99.7
68	1	10	765	0	765	1,530	4	1	0	5	99.7
52	1	10	714	0	714	1,428	3	1	0	4	99.7
17	1	10	562	0	562	1,124	4	0	0	4	99.6
7	1	10	477	0	477	954	4	0	0	4	99.6
46	1	10	888	0	888	1,776	6	2	0	8	99.6
36	1	10	156	0	156	312	2	0	0	2	99.4
49	1	10	790	0	790	1,580	10	0	0	10	99.4
54	1	10	804	0	804	1,608	8	3	0	11	99.3
79	1	10	346	0	346	692	2	3	0	5	99.3
11	1	10	668	0	668	1,336	9	1	0	10	99.3
63	1	10	892	0	892	1,784	18	1	0	19	98.9
69	1	10	865	0	865	1,730	7	12	0	19	98.9
23	1	10	615	0	615	1,230	14	2	0	16	98.7
55	1	10	513	0	513	1,026	15	1	0	16	98.4
80	1	10	475	0	475	950	17	0	0	17	98.2
64	1	10	379	0	379	758	13	3	0	16	97.9
22	1	10	863	0	863	1,726	47	0	0	47	97.3
31	1	10	643	0	643	1,286	43	0	0	43	96.7
29	1	10	896	0	896	1,792	91	0	0	91	94.9
34A	1	10	546	0	546	1,092	54	4	0	58	94.7
53A	1	10	576	0	576	1,152	63	0	0	63	94.5
9	1	10	333	0	333	666	40	0	0	40	94.0
58	1	10	648	0	648	1,296	92	1	0	93	92.8
35	1	10	739	0	739	1,478	120	2	0	122	91.7
57	1	10	975	0	975	1,950	171	0	0	171	91.2
26	1	10	352	0	352	704	65	0	0	65	90.8
16	1	10	719	0	719	1,438	165	0	0	165	88.5
62	1	10	792	0	792	1,584	266	21	0	287	81.9
Total	30	300	19,283	0	19,283	38,566	1,356	59	0	1,415	96.3

Table 12.--Summary of mortality sampling, by control units, 1955 Oregon spruce budworm control project

Spray block number	Number of samples: Lines	Stations	Population before spraying: Larvae	Pupae	Total	Total 2x	Population after spraying: Larvae	Pupae	Emerged pupae	Total	Mortality percent
CATHERINE CREEK CONTROL UNIT											
C-1	1	10	50	0	50	100	0	0	0	0	100.0
C-2	1	10	352	0	352	704	0	0	0	0	100.0
C-7	1	10	306	0	306	612	1	1	0	2	99.7
C-3	1	10	49	0	49	98	0	1	0	1	99.0
Total	4	40	757	0	757	1,514	1	2	0	3	99.8
POWDER RIVER CONTROL UNIT											
P-2	1	5	246	0	246	492	0	0	0	0	100.0
P-10	1	10	515	0	515	1,030	0	1	0	1	99.9
P-5	1	10	689	0	689	1,378	3	3	0	6	99.6
P-6	1	10	375	0	375	750	5	1	0	6	99.2
P-17	1	9	63	0	63	126	1	0	0	1	99.2
P-16	1	10	150	0	150	300	0	4	0	4	98.7
P-14	1	10	747	0	747	1,494	22	0	0	22	98.5
P-22	1	10	284	0	284	568	9	0	0	9	98.4
P-37	1	5	258	0	258	516	9	0	0	9	98.3
P-12	1	10	533	0	533	1,066	5	0	7	12	98.9
P-26	1	10	781	0	781	1,562	37	0	0	37	97.6
P-32	1	10	334	0	334	668	5	9	5	19	97.2
P-35	1	10	659	0	659	1,318	39	1	0	40	97.0
P-33	1	8	420	0	420	840	30	0	0	30	96.4
P-11	1	8	116	0	116	232	2	7	3	12	94.8
P-9	1	10	323	0	323	646	42	0	0	42	93.5
P-41	1	3	158	0	158	316	46	0	0	46	85.4
P-38	1	5	70	2	72	144	11	14	0	25	82.6
Total	18	153	6,721	2	6,723	13,446	266	40	15	321	97.6

Table 12 (Cont.)--Summary of mortality sampling, by control units, 1955 Oregon spruce budworm control project

Spray block number	Number of samples: Lines	Number of samples: Stations	Population before spraying: Larvae	Population before spraying: Pupae	Population before spraying: Total	Population before spraying: Total 2x	Population after spraying: Larvae	Population after spraying: Pupae	Population after spraying: Emerged pupae	Population after spraying: Total	Mortality percent
EAGLE CREEK CONTROL UNIT											
E-11	1	2	49	0	49	98	0	0	0	0	100.0
E-1	1	10	159	0	159	318	0	0	0	0	100.0
E-8	1	10	310	0	310	620	5	0	0	5	99.2
E-15	1	10	324	0	324	648	4	2	0	6	99.1
E-10	1	10	451	0	451	902	54	0	0	54	94.0
E-19	1	10	615	0	615	1,230	80	1	0	81	93.4
E-3	1	10	225	0	225	450	39	9	0	48	89.3
Total	7	62	2,133	0	2,133	4,266	182	12	0	194	95.5
Project total	80	754	42,122	2	42,124	84,244	2,424	167	15	2,616	96.9

Roster of active participants, 1955 Oregon spruce budworm control project

PROJECT ADMINISTRATION

U. S. Forest Service

Project Director	A. Jaenicke
Asst. Project Director	C. Wessela
Supply Officer	F. Walisch
Asst. Supply Officer	W. Clarke
Safety Officer	R. Lindberg
Chief Pilot	M. Pierce
Insecticide Sampling	H. LaBarre

PNW Forest & Range Experiment Station

Entomologist in Charge	R. Furniss
Technical Director	J. Whiteside

USDA Agricultural Research Services

Insecticide Testing	Dr. W. Westlake

Oregon State Board of Forestry

State Forester	G. Spaur
Asst. Project Director	L. Compton
Operations Coordinator	A. Larsen

Interstate Services Companies

Dispatcher	M. Lennington

Pennsylvania Salt Mfg. Co. of Wash.

Chief Chemist	S. Waterman
Asst. Chemist	K. Earnest

CONTROLL UNIT PERSONNEL

Assignment	Ochoco unit	Malheur Susanville units	Catherine Creek Powder River Eagle Creek units
Transportation Contractor			
Chief Representative	M. Lennington	M. Lennington	M. Lennington
Pump Technician	G. Beckman	G. Bacon	J. Berger
Spraying Contractor			
Chief Representative	R. Baxter	A. Livingston	F. Devlin
Contractor's Bookkeeper		W. Morse	
Chief Pilot	J. Seller	C. Butler	F. Devlin

Roster (Cont.)

Assignment	Ochoco unit	Malheur Susanville units	Catherine Creek Powder River Eagle Creek units
Spraying Contractor (cont.)			
Spray Pilots	A. Berkes G. Bulkley A. Fuller R. Gardner M. Hartley L. Henderson T. Howard D. Kyte M. Mann J. Moberg E. Nelson W. Olsen R. Osborne R. Poet L. Reich C. Robinson H. Thierman J. Vogan W. Walker	D. Black F. Christiansen R. Cummings M. Curtis T. Dekallis J. Edwards E. Downs D. Franklin E. Henderson H. Henderson J. Inman J. Jeldness T. McCart R. Morgan C. Munger J. Nielsen R. Putman J. Retterath T. Shannon J. Shoun C. Snodgrass W. Spencer J. Williams	L. Adams E. Ball M. Bowler C. Curtis G. Doyle B. Gilbert J. Jeldness C. Lemons J. Loney E. Martindale E. Phillips N. Ralston H. Trunnell P. Walker R. Waltermeir Williams G. Wilson
Co-Pilots	F. Carlson		H. Coder R. Yates
Observation Pilots	P. Crocker K. Heppner A. Ketchum	C. Butler E. Liston A. Livingston	O. Crismon F. Devlin

Roster (Cont.)

Assignment	Ochoco unit	Malheur Susanville units	Catherine Creek Powder River Eagle Creek units
Spraying Contractor (cont.)			
Chief Mechanic	R. Mooney	C. Powers	D. Magee
Mechanics	H. Olson	J. Snider	M. Sayko
	M. Webster	T. Steinbock	E. Frank
Mechanic's Helpers	R. Carrier	C. Battrick	J. Bibberstein
	A. Engle	B. Downs	D. Harris
	R. Reed	R. Taylor	J. Longteig
		C. Tunnell	H. Major
Insecticide Loaders	H. Davidson	W. Ayers	J. Bloan
	J. Dawson	W. Battrick	C. Christensen
	K. Fuller	V. Gregory	H. Conelly
	G. Gordon	W. Hartfield	L. Davis
	M. Mathews	E. Miller	D. Jacobs
		B. Seely	D. Justus
			L. Martindale
Civil Aeronautics Administration			
Safety Agents	R. Byrd	H. Lane	T. Smith
	R. Kagy	R. Kagy	R. Kagy
Unit Administration			
Unit Supervisors	J. Ralph	J. Gjertson	D. McComb
Asst. Unit Supervisors	F. Ferrarelli	R. Hribernick	D. Crumb
	M. McCoy	C. McKee	
Technical Assistant			A. Gruba
Biologists	D. James	R. Lemmon	D. Bishop*
Insect Checkers	R. Rensel	K. Dalton	H. Elrod
	G. Wise	R. Primozic	D. Sheridan

* R. Schoener was Biologist from May 9 to June 15; D. Bishop was Biologist from June 15 to July 30.

Roster (Cont.)

Assignment	Ochoco unit	Malheur Susanville units	Catherine Creek Powder River Eagle Creek units
Unit Administration (Cont.)			
Plate Checkers	R. Beck C. Bray W. Hardin R. Tavernia	K. Cromwell J. Justice C. Clein H. Thomason W. Winegar	R. Glasgow G. Wiltsey
Load Checkers	R. Calkin J. Huges J. Lowe P. Morris S. Wallich	C. Dannen W. Downing W. Williams	R. Harrell L. Hurse D. Houlton D. Smith
Flight Checkers	D. Kinnard	D. McPherson	
Radio Operators	L. Bowman	D. Sikes	
Weather Observers	Mr. & Mrs. Drury Mr. & Mrs. Van Bibber C. Hilton	N. Huffaker D. Jorgensen R. Pemberton	D. Swartz R. Wilcox
Sprinkler Truck Operator	J. Welsch	G. Dustin	
Camp Bosses	A. Mason	W. Kane	
Cooks	Mrs. N. Mason Mrs. D. Cameron	J. Peterson C. Perry	
Bull Cooks	C. Lochre L. Belle O. Potter	G. Fischer J. Kohl R. Spradlin	
Search & Rescue Squad #1	W. Boring R. Calkin J. Ralph	J. Arne H. McCormick M. Schouten	M. Compton A. Gruba A. Larsen
Search & Rescue Squad #2		A. Smith O. Cummings A. Oard	

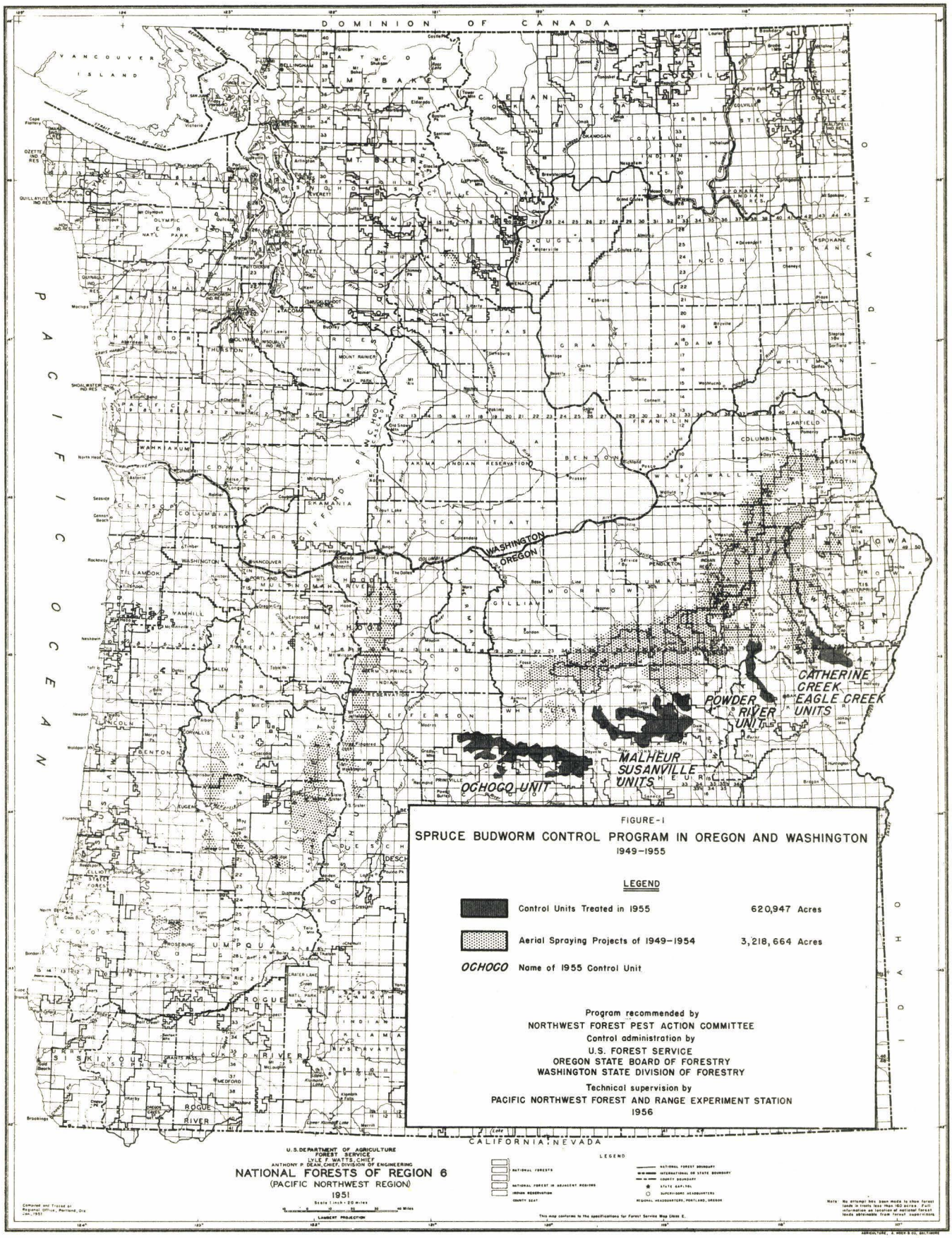


FIGURE-1

SPRUCE BUDWORM CONTROL PROGRAM IN OREGON AND WASHINGTON
1949–1955

LEGEND

	Control Units Treated in 1955	620,947 Acres
	Aerial Spraying Projects of 1949–1954	3,218,664 Acres
OCHOCO	Name of 1955 Control Unit	

Program recommended by
NORTHWEST FOREST PEST ACTION COMMITTEE
Control administration by
U.S. FOREST SERVICE
OREGON STATE BOARD OF FORESTRY
WASHINGTON STATE DIVISION OF FORESTRY
Technical supervision by
PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
1956

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
LYLE F. WATTS, CHIEF
ANTHONY P. DEAN, CHIEF, DIVISION OF ENGINEERING

NATIONAL FORESTS OF REGION 6
(PACIFIC NORTHWEST REGION)
1951

Scale 1 inch = 20 miles
LAMBERT PROJECTION

Compiled and Traced at Regional Office, Portland, Ore. Jan., 1951

LEGEND
NATIONAL FORESTS
NATIONAL FOREST IN ADJACENT REGIONS
INDIAN RESERVATION
COUNTY SEAT
NATIONAL FOREST BOUNDARY
INTERNATIONAL OR STATE BOUNDARY
COUNTY BOUNDARY
STATE CAPITOL
SUPERVISORS' HEADQUARTERS
REGIONAL HEADQUARTERS, PORTLAND, OREGON

This map conforms to the specifications for Forest Service Map Class E.

Note: No attempt has been made to show forest lands in tracts less than 160 acres. Full information on location of national forest lands obtainable from forest supervisors.

AGRICULTURE, R. HOE & CO., BALTIMORE